

Basic investigations on LCV micelle gel

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Abstract. The aim of this study was to investigate the feasibility of using Leuco Crystal Violet (LCV) based micelle gel dosimeter as a quality assurance tool in radiotherapy applications. Basic properties such as absorption coefficient and diffusion of LCV gel phantom over time were evaluated. The gel formulation consisted of 25 mM Trichloroacetic acid, 1mM LCV, 4 mM Triton X-100, 4% gelatin by mass and distilled water. The advantages of using this gel are its tissue equivalence, easy and less preparation time, lower diffusion rate and it can be read with an optical scanner. We were able to reproduce some of the results of Babic et al. The peak absorption was found to be at 600 nm and hence a matrix of yellow LEDs was used as light source. The profiles obtained from projection images confirmed the diffusion of LCV gel after 6 hours of irradiation. Hence the LCV gel phantom should be read before 6 hours post irradiation to get accurate dose information as suggested previously.

1. Introduction

Verification of complex modern radiation therapy techniques such as 3-D CRT and IMRT need an integrating dosimeter that is tissue equivalent with good spatial resolution for dose verification [1-8]. In Fricke gel dosimetry, diffusion of the dose distribution [9, 10] after 2 hours creates inconvenience in the use of gel as a regular quality assurance tool.

Jordan et al developed a radiochromic hydrogel leuco crystal violet (LCV) micelle gel that has a low diffusion when compared to other gels [11]. An in-house optical cone beam CT (CBCT) scanner using yellow LED light source was used for evaluating the LCV gel dosimeter. In this study the absorption co-efficient and the diffusion of the LCV gel have been investigated.

2. Methods and Materials

2.1. Gel Preparation

The components used for the preparation of this gel was 4% w/w gelatin (Sigma, 300 bloom), 25 mM Trichloroacetic acid, (Sigma Aldrich), 1mM LCV, 4 mM Triton X-100 (Sigma) and triple distilled water. Gelatin was added to distilled water and heated to 30°C with continuous stirring for 1 hour. Trichloroacetic acid, LCV and Triton X-100 were mixed together in distilled water and stirred at 45°C for 30 minutes.

The two solutions were mixed after bringing the temperature of the second solution from 45°C to 30°C and stirred thoroughly for 10 minutes. The resulting pale-bluish violet coloured gel was poured into cylindrical phantoms (figure 1) (bulk gel of 1 Litre capacity) and cuvettes (figure 2) (4 ml volume). The gel phantoms were kept in the refrigerator at 4°C until gelation.



2.2. Irradiation

The cylindrical gel phantom was irradiated to a dose of 30 Gy at a depth of 10 cm in the phantom using a 1.5 cm stereotactic cone attached to a Siemens Primus linear accelerator (Siemens, USA) that delivered 15 MV photons to the gel.

The cuvettes were kept in a water bath and irradiated with different doses on a Cobalt-60 teletherapy unit with lateral and backscatter conditions to find the attenuation data of the LCV gel.



Figure 1: Irradiation setup of Bulk gel

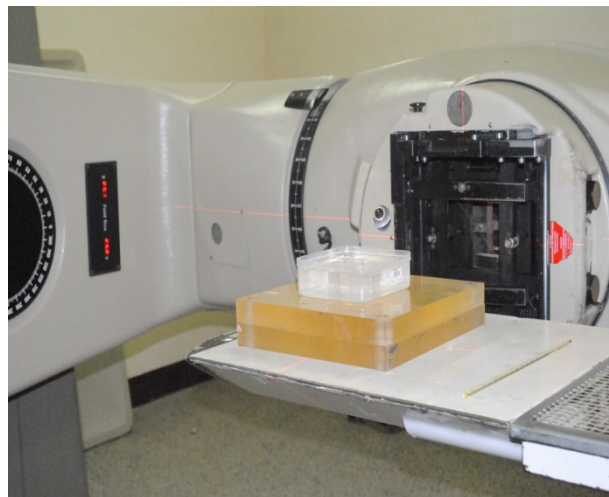


Figure 2: Irradiation setup of gel in cuvettes

2.3. Read out system

An in-house optical CBCT scanner was used for reading the dose matrix embedded in the gel phantoms. This scanner consisted of an aquarium of size 26 x 26 x 20 cm³ with a turntable (rotated by a 4 pole stepper motor controlled with a computer) with angular graduations of 1 degree, a matrix of yellow LEDs as light source and a high resolution camera (Point Gray Fly Capture Camera) as a detector. The maximum resolution of the detector is 1024 x 768. 3D projection images (640 x 480) were obtained for 360 degrees. Reduction gears were used to ensure 1 degree rotations for every pulse sent to the stepper motor.

2.3.1. Optimal Readout wavelength determination.

For determining the optimal wavelength at which the LCV gel displays maximum absorption, the irradiated cuvettes with gel were read in a spectrophotometer (Schimadzu) for various wavelengths.

2.4. Gel Reconstruction

A pre and post irradiation scan of the phantom was carried out. The scans were performed with a time gap of 20 minutes, 1 hour, 2 hours, up to 6 hours 30 minutes and 7 hours post irradiation. Since the room temperature was at 32°C, the water in the aquarium was maintained at 22°C considering the melting point for LCV gel at 29°C. The post irradiation scans were also performed at 12 and 19 hours.

The ratio of the pre and post scan data was obtained and the CT reconstruction of the optical attenuation was performed with 'ifanbeam' functions implemented in Matlab 7.5.0. Figure 3 shows the Matlab reconstructed dose distribution applying 'ifanbeam' function.

3. Results and Discussion

It was observed that the LCV gel under investigation had the peak absorption (figure 5) at a wavelength of 600 nm. The profiles obtained from the projection images of the bulk gel phantom (figure 6) showed no diffusion till 6 hours post irradiation and significant diffusion [11-13] when scanned at 6 hours 30 minutes post irradiation. However, the FWHM (Full width at Half Maximum)

measured from the profiles (figure 4) obtained from reconstructed data did not show any diffusion in the scans done till 7 hours post irradiation and a mild change after 7 hours.

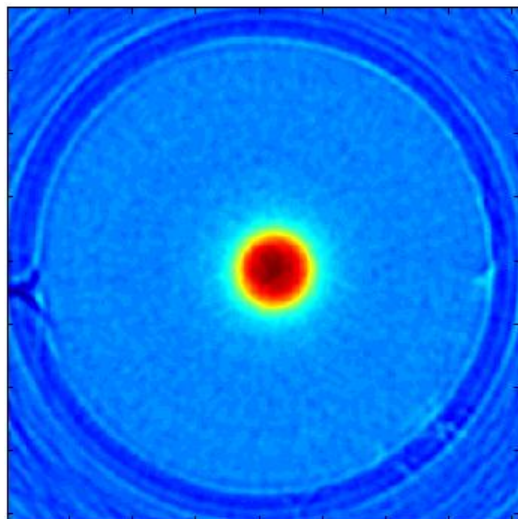


Figure 3: Reconstructed Dose

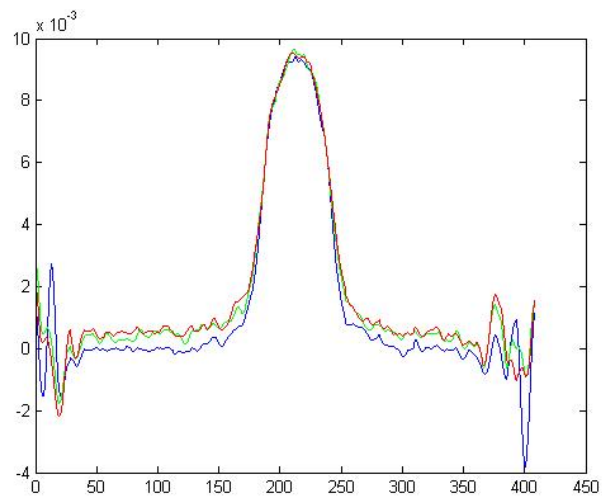


Figure 4: FWHM at 20 mins (blue), 6 hrs (green) and 6.5 hrs (red) post irradiation

Absorption spectrum for LCV gel

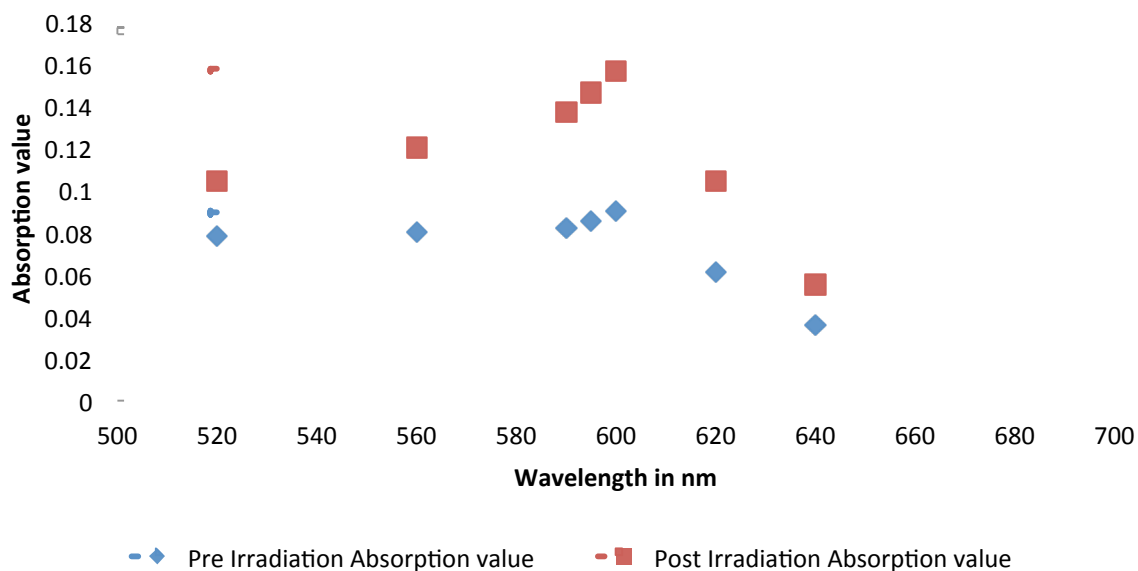


Figure 5: Plot showing the absorption spectrum of LCV gel irradiated to 20 Gy

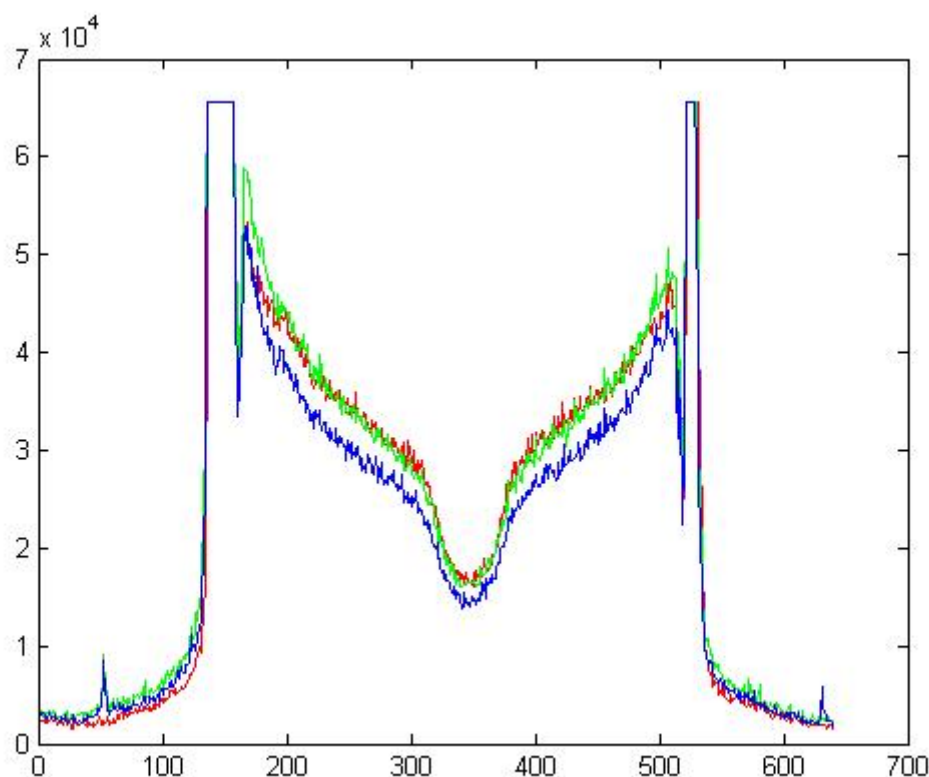


Figure 6: Profiles from projection images showing diffusion over time. 20 minutes (Red), 6 hours (Green) and 6.5 hours (Blue).

4. Conclusion

The feasibility of using the LCV gel with an optical CBCT scanner for radiotherapy dosimetry has been investigated. We were able to reproduce some previous published results [11-13]. Due to its lower diffusion rate compared to FX gel, it is concluded that the LCV gel scanned using optical CBCT scanner with a light source of wavelength 600 nm can be used as a 3D verification tool for high precision radiation therapy. As suggested by the previous authors [11-13] post irradiation scans should be performed before 6 hours to get accurate dose distribution. Care should be taken to keep the temperature low since this gel melts at 29°C. Further work should involve making this gel more radiosensitive.

5. References

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